Cotton crops *versus* weeds: when is the competition period?

In Africa, cotton crops are often first weeded when weed competition is already high. Is there a crucial period during which weed infestation is particularly harmful? Three years of research have provided an answer to this question.

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In agriculture, it is essential to determine when crops will be the most and least harmed by weeds. DECOIN (1992) noted that some weed infestations can have a less serious impact on crops than their visual appearance would indicate. For NIETO, quoted by GURNAH (1974), cropfields have to be kept clear of weeds during "critical periods" of the crop growth cycle in order to achieve maximum yields. CAUSSANEL (1989) defines this as the period during which the presence of weeds can lead to measurable yield losses. This is the prime period for conducting weeding operations, with the following factors also having a considerable influence: the environment, the extent of weed infestation in the cropfield, the weed flora composition, crop density, etc.

For example, according to KASASIAN & SEEYAVE (1969), in Jamaica, Trinidad and Tobago, the critical period for weed competition is 2-4 weeks after sowing for French beans *(Phaseolus vulgaris)* and 3 weeks after sowing for sweet potatoes *(Ipomoea batatas)*. According to the same authors and under the

Brachiaria lata.
Photo M. Déat

Experiments with cotton crops

This study was carried out from 1988 to 1990 at the Anié-Mono research station in Togo, on vertisol, with 1 100 to 1 200 mm annual rainfall (Figure 1). The trials were conducted in plots cropped with rainfed cotton *(Gossypium hirsutum)*, involving varieties with a 160-day cycle (Stam F, 1988; Stam 45-E, 1989; Stam F-59, 1990). The cotton plants were sown on ridges at 0.80 m x 0.30 m spacing (theoretical planting rate: 41 666 plants/ha). The cultivation period was from July to December. Rainfall during this period was 556 mm (1988), 771 mm (1989) and 475 mm (1990). The plots were fertilized and treated with pesticides.

Methods

The method for determining critical periods in the crop growth cycle, from the studies of NIETO, PETERS, WEARER & DAWSON, as quoted by CAUSSANEL (1989), was based on the results of an experiment involving two series of trials aimed at analysing yield in terms of competition time. In the first series, weeds were allowed to grow freely for progressively longer periods after sowing before they were controlled, in order to determine early competition (Ce). In the second series, the cropped plot was kept weed-free from sowing until progressively later dates, in order to assess late competition (Cl).

Experimental design

A randomised Fisher block design with 8 repeats was used for this study. There were four ridges, 10 m long x 0.80 m apart, on each basic plot.

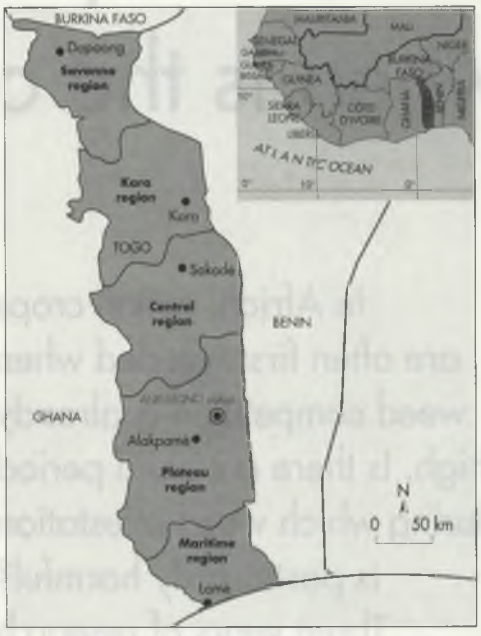

Figure 1. Trial sites in Togo.

Early competition treatments:
The plots were kept weed-free from the indicated first weeding date.

Plot code	W1	W2	W3	W4	W5	W6	W7	W8	W9
Sowing date	14	21	28	35	42	49	56	63	70

Date of the first weeding (number of days after sowing)

Late competition treatments:
The plots were kept weed-free from sowing until the indicated last weeding date.

Plot code	W10	W11	W12	W13	W14	W15	W16	W17	W18
Sowing date	14	21	28	35	42	49	56	63	70

Date of the last weeding (number of days after sowing)

The plots were weeded every 14 days after the first weeding or before the last
Plot W19 was weeded throughout the crop cycle
Plot W20 was never weeded
Plot W21 was weeded 20 days and 40 days after sowing
Plot W22 was treated with a pre-emergence herbicide then weeded

Figure 2. Description of the trial plots.

Only the two central ridges on each plot were monitored. All tests over the 3-year study period were conducted at the same site. However, a new random distribution of field treatments was done each year.

Treatments

The different treatments were as follows (Figure 2):

– plots assigned to the early competition groups were weeded from the date indicated in the protocol. Subsequent weeding was done every 14 days until crop development was considered sufficient;

– for the late competition group, the plots were kept weed-free from sowing until the date of the last weeding established in the protocol. The first weeding began 14 days after sowing and was repeated every 2 weeks thereafter;

– the weed-free control plot W19 (regular maintenance) was weeded 7 days after sowing, then weekly. Weeding was stopped when the cotton plants had grown sufficiently;

– plot W20 (no maintenance) was not weeded during the crop cycle, whereas plot W21 (recommended maintenance) was weeded for the first time on day 20, and then weeded and earthed-up on day 40;

– plot W22 was treated with a pre-emergence herbicide combining dipropetryn (240 g/l) and metolachlor (160 g/l), at a dose of 1 600 g/ha of total active ingredient. After the herbicide took effect, the plot was manually weeded when necessary.

At each weeding, flora inventories are conducted, while noting weed abundance. Final cottonseed yields were also determined.

same conditions, weed infestations can be very harmful to tomato *(Lycopersicum esculentum)* crops within the first 30 days following transplanting. Weed competition can also have a serious impact on other crops over extended periods, e.g. yam (*Dioscorea* spp.) throughout its growing cycle (KASASIAN & SEEYAVE, quoted by GURNAH, 1974). In Sudan, the critical period for most crops is 4-6 weeks after sowing (CROWTHER, quoted by HAMDOUM & TIGANI, 1977). NIETO *et al.* (1968) demonstrated that weed cover threatened maize crops in Mexico within the first 30 days post-emergence. In Togo, this period occurs 10-24 days after sowing (SCHMID *et al.*, 1983). In rainfed rice cropfields in southern Togo, weed competition is most serious 21-30 days after sowing (BOYODA, 1991).

In addition, on the basis of agronomic and economic analyses conducted in five villages in Togo from 1983 to 1988 (COUSINIE *et al.*, 1989), herbicide experiments were carried out in smallholders' cotton cropfields from 1987 to 1989 (FAURE *et al.*, 1988; TONATO *et al.*, 1989 & 1990). The results revealed that farmers generally weeded their fields once or twice (extension services often recommend two weedings), but these operations were often too late. Since the technical guidelines established for cotton cropping were insufficient, a 3-year study was undertaken (1988-1990) to identify the weed flora and the critical period for weed competition with respect to cotton.

Weed flora identification

Over the study period, 37 weed species were identified in 1988, 42 in 1989 and 46 in 1990 (Table 1).

There were always substantially higher numbers of broad-leaved species as compared to Cyperaceae and Poaceae species. However, the latter group was generally dominant in terms of overall plant numbers (quantitative dominance).

Brachiaria lata (Schumacher) C.E. Hubbard, the most common weed in 1988 and 1989, was dominated by *Echinochloa colona* (L.) Link in 1990. In 1988, *B. lata* was so dominant that the weed population was considered monospecific in this trial.

Table 1. Number of species inventoried.

Weed group	1988	1989	1990
Poaceae & Cyperaceae	9	12	13
Broad-leaved species	28	30	33
Total	37	42	46

Phyllanthus amarus.
Photo CIRAD-AMATROP

Apart from changes in weed flora concerning *B. lata* and *E. colona, Cynodon dactylon* (L.) Pers., which was relatively scarce in 1988, flourished in the following years. Some cultivation practices promote the propagation of this stolon- and rhizome-bearing plant: ploughing, cross-harrowing (disking), etc. Infestations of *Cyperus esculentus* L., *Cyperus rotundus* (L.) and *Digitaria horizontalis* Willdenov also increased. Weed flora patterns therefore changed over time, notably an increase in *C. dactylon,* which was generally responsible for the intra-block heterogeneity noted in 1990.

The main weeds encountered yearly over the 3-year study, in order of importance, were:

– 1988: *B. lata* and *Phyllanthus amarus* Schumacher & Thonning;

– 1989: *B. lata, C. esculentus, C. dactylon* and *Phyllanthus amarus;*

– 1990: *E. colona, B. lata, C. dactylon, C. esculentus, D. horizontalis* and *P. amarus.*

Cyperus esculentus.
Photo H. Merlier

A marked influence of competition periods

Gross cottonseed yields (observed and relative) obtained in the 1988 and 1989 trials are given in Table 2. They were calculated in relation to a weed-free control (W19). The 1990 results were not taken into account in the analysis of means, because of the high heterogeneity induced by weed flora changes (dominance of *C. dactylon* in patches) and by the loss of plants during their growth cycle. The mean cottonseed yields per plot for the 1988-1989 period indicated a production potential of around 2 000 kg/ha of cottonseed, for the varieties studied, in the weed-free control (W19), whereas the unweeded control (W20) yielded only one tenth of this (200 kg/ha).

In the early competition group, mean cottonseed yields were equal to that of the weed-free control when the first weeding was performed 14, 21 or 28 days after sowing (plots W1-W3). There were significant yield differences relative to the weed-free control when this first weeding was done 35 days after sowing or later.

For the late competition group treatments, the results did not differ significantly from the weed-free control when weeding was stopped 42-70 days after sowing (plots W14-W18). Under our experimental conditions, only plots in which weeding was stopped 14, 21, 28 or 35 days after sowing (plots W10-W13) gave significantly lower yields than the weed-free control.

For the treatment with two weedings (E21), at 20 and 40 days after sowing, and the treatment with a herbicide treatment and weeding (W22), the cottonseed yields did not differ significantly from that obtained on the weed-free control plot.

Competition thresholds

The early weed competition threshold is defined as the date of the first weeding after which a significant difference in crop yields, relative to a permanently weed-free control, is recorded. The late weed competition threshold is the date of the last weeding beyond which a significant difference in crop yields, as compared to the weed-free control, is not observed.

Table 2. Cottonseed yields obtained for the different treatments (means of 1988 and 1989 results, for which yields were very similar, in kg/ha and percentage relative to the weed-free control W19).

Treatment	Mean yield 1988-1989 (kg/ha)	Result % of W19	Significance
Early competition			
W1	1 788	97	Results
W2	1 731	94	not significantly
W3	1 644	89	different from control
Late competition			
W14	1 728	94	
W15	1 639	89	
W16	1 757	95	
W17	1 780	96	
W18	1 800	98	
Weed-free control			
W19	1 845	100	
Smallholder plot			
W21	1 645	89	
Plot with herbicide			
W22	1 705	92	
Early competition			
W4	1 375	75	Results
W5	1 411	76	significantly
W6	1 051	57	different from
W7	969	53	control
W8	806	44	
W9	676	37	
Late competition			
W10	579	31	
W11	953	52	
W12	1 239	67	
W13	1 488	81	
Unweeded control			
W20	233	13	
Mean	1 356		
Coefficient of variation	11.5		

Dunnett's Test, 5% significance threshold, relative to control W19.

Under our experimental conditions, the early weed competition threshold (Te) occurred 28-35 days after sowing and the late weed competition threshold (Tl) was 35-42 days after sowing. The critical period for weed competition (Cw) was estimated as the time interval between these two thresholds, i.e. 28-42 days after sowing (Figure 3). NIETO *et al.* (1968) stated that weeds should theoretically be destroyed during this period.

Te: early competition threshold; Tl: late competition threshold; Ce: early competition; Cl: late competition; Wp: permanent weeding; Pc: critical period for weed competition

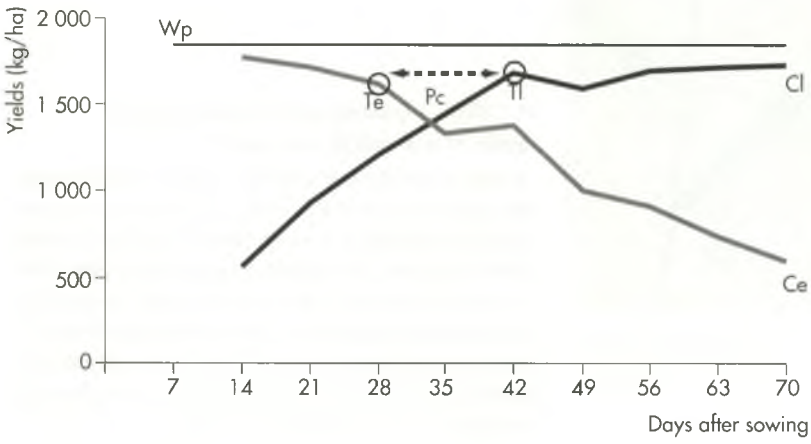

Figure 3. Cottonseed yields in plots subjected to early competition (Ce) and those subjected to late competition (Cl). Determination of critical period (Pc) for weed competition in cotton cropfields.

Conclusion

Now that this critical period has been established, it would be of interest to clarify certain aspects of weed competition with cotton crops.

Several maintenance conditions should be defined and compared:
– how should cotton crops be kept weed-free during the critical period?
– is it important to weed before and after this period?
– are three successive weedings efficient: a first weeding within 28 days after sowing, a second during the critical period, and a third after 42 days?
– is the technique involving treatment with a pre-emergence herbicide followed (if necessary) by manual weeding sufficiently effective?

Commelina benghalensis.
Photo H. Merlier

Critical period for weed competition in cotton cropfields

In the present study, the critical period for weed competition was approximated for cotton crops in Togo (28-42 days after sowing), and the detrimental effects of early weed competition was demonstrated. The graphs in Figure 3 highlight a serious cottonseed yield loss due to early weed competition and a much smaller loss due to late competition. The differences recorded in 1990 indicate that these conclusions are not definitive, as the environment and spatial distribution of weed species are important factors that require further consideration.

When are the critical periods for weed competition in other countries?

The critical period varies in different countries. The results of a study of SCHWERZEL & THOMAS (1971) in Zimbabwe (1967-1969) showed that the critical period for weed competition in out-of-season irrigated cotton fields was 2-4 weeks post-emergence, while in rainfed cotton cropfields this critical period was as late as 6-8 weeks post-emergence. In Columbia, according to PERDONO quoted by SCHWERZEL & THOMAS (1971), this period extends from the 20th to the 45th day post-emergence for cotton. These results are close to those obtained in Togo. PERDONO confirmed that weed competition is no longer detrimental to cotton crops after 45 days. In Tanzania, the critical period for cotton ranges from 30 to 75 days after sowing (SAKIRA, quoted by GURNAH, 1974), whereas in Maharashtra State in India, SHELKE & BHOSLE (1990) found that this period ranged from 20 to 60 days after sowing.

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Echinochloa colona.
Photo T. Le Bourgeois

Abstract... Résumé... Resumen

P. Y. DOUTI — **Cotton crops *versus* weeds: when is the competition period?**

In Togo, weed control operations are often late in cotton fields. However, previous studies have shown that fields must be well maintained in order to obtain good yields. An experiment carried out from 1988 to 1990 revealed the critical period when weed competition is the most serious for cotton crops, i.e. 28-42 days after sowing. These results will help in determining weed control alternatives to precisely target field control operations.

Keywords: cotton, weed, competition, weeding, Togo.

P. Y. DOUTI — **Cotonnier contre mauvaises herbes : quelle est la période de concurrence ?**

Au Togo, les premières interventions de sarclage en culture cotonnière paysanne sont souvent tardives. Or, des travaux antérieurs ont montré que l'entretien est le premier facteur limitant pour l'obtention de bons rendements. Une expérimentation conduite de 1988 à 1990 a permis de déterminer la période critique au cours de laquelle la concurrence des mauvaises herbes est la plus défavorable. Cette période se situe entre 28 et 42 jours après le semis. La détermination de la période critique permet d'identifier des alternatives d'entretien pour un meilleur ciblage des interventions au champ.

Mots-clés : cotonnier, mauvaise herbe, concurrence, désherbage, Togo.

P.- Y. DOUTI — **Algodón contra malezas: ¿Cuál es el periodo de competencia?**

En Togo, las primeras intervenciones de escarda en el cultivo algodonero campesino suelen ser tardías. Ahora bien, unos trabajos anteriores demostraron que el mantenimiento es el primer factor limitativo para la obtención de buenos rendimientos. Una experiencia llevada a cabo de 1988 a 1990 permitió determinar el periodo crítico durante el cual la competencia de las malezas es la más desfavorable. Dicho periodo se sitúa entre 28 y 42 días después de la siembra. Esta determinación del periodo crítico permite pues encontrar alternativas de mantenimiento para definir más precisamente las intervenciones en el campo.

Palabras clave: algodón, maleza, competencia, escardadura, Togo.